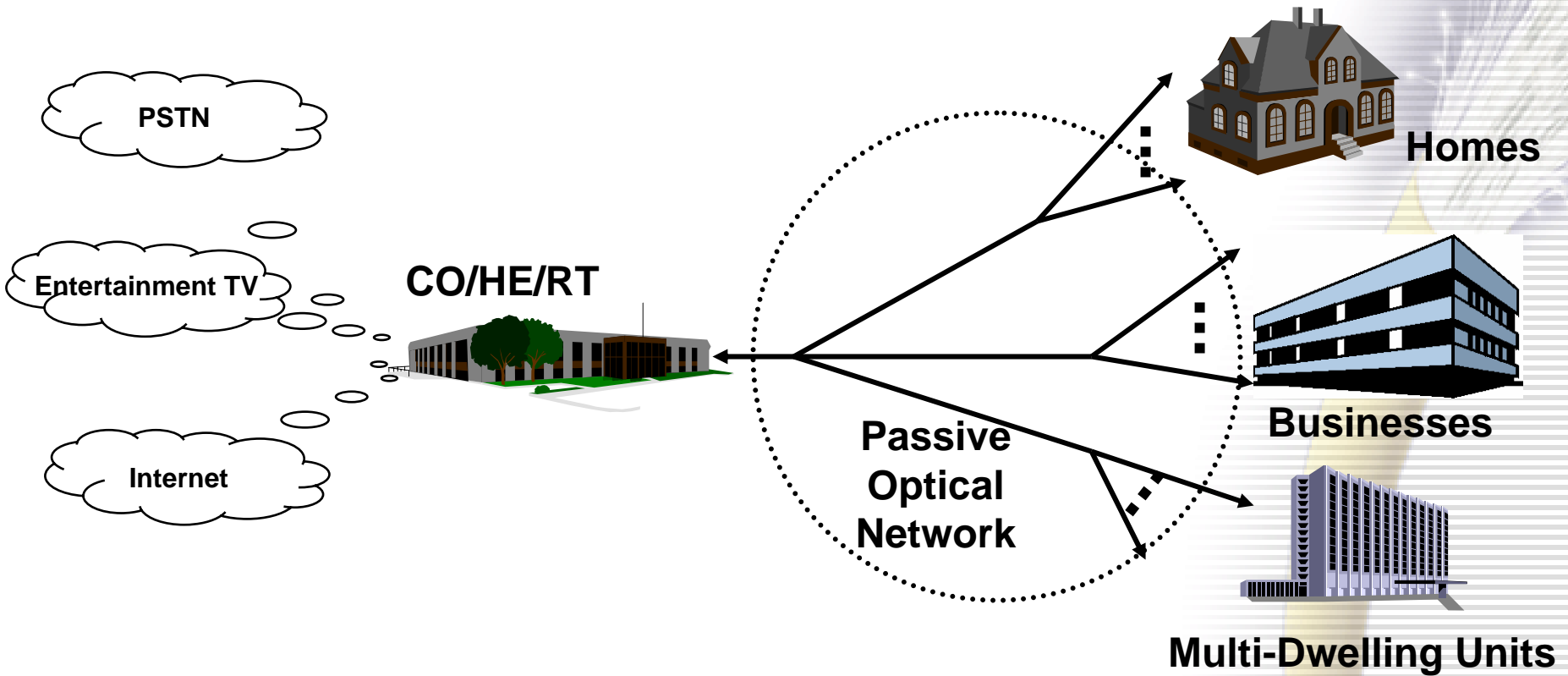# Overview of Passive Optical Networks (PONs)

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(763) 268-3505

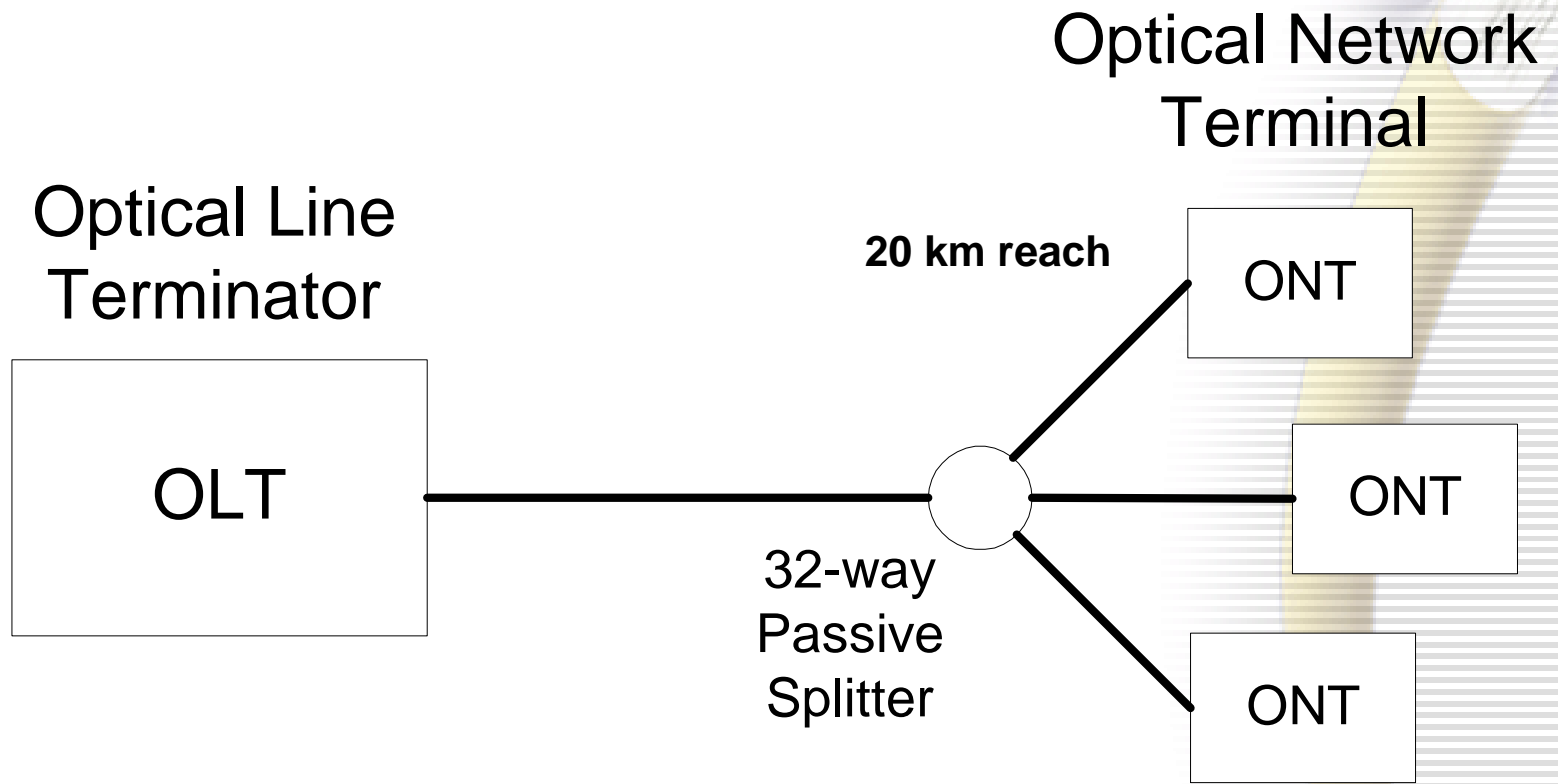www.opticalsolutions.com

Optical Solutions®
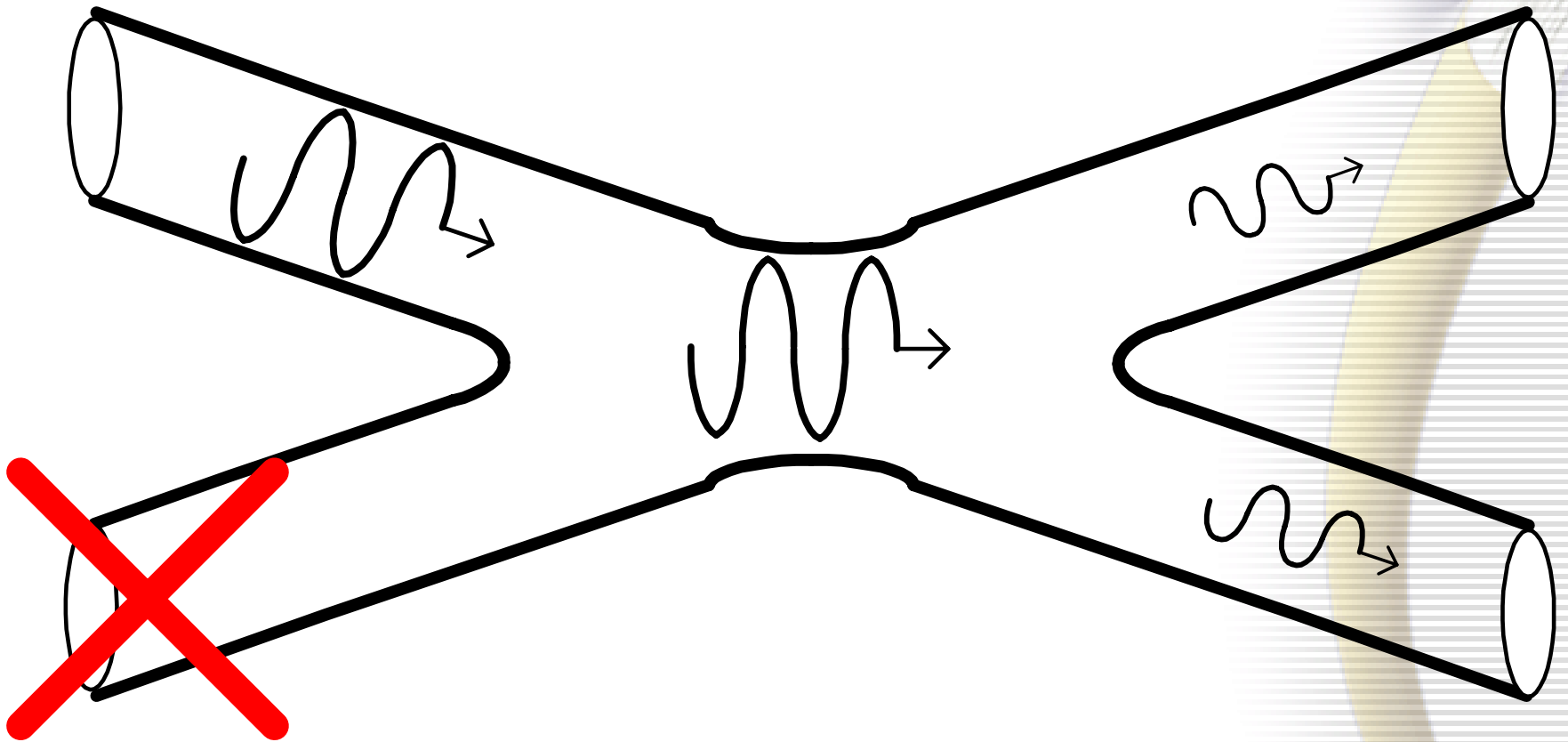
Fiber Powered Communities

PON Access Network

The Physical Layer of a PON

Simplified PON

Optical Line
Terminator

Optical Network
Terminal

20 km reach

| OLT |

32-way
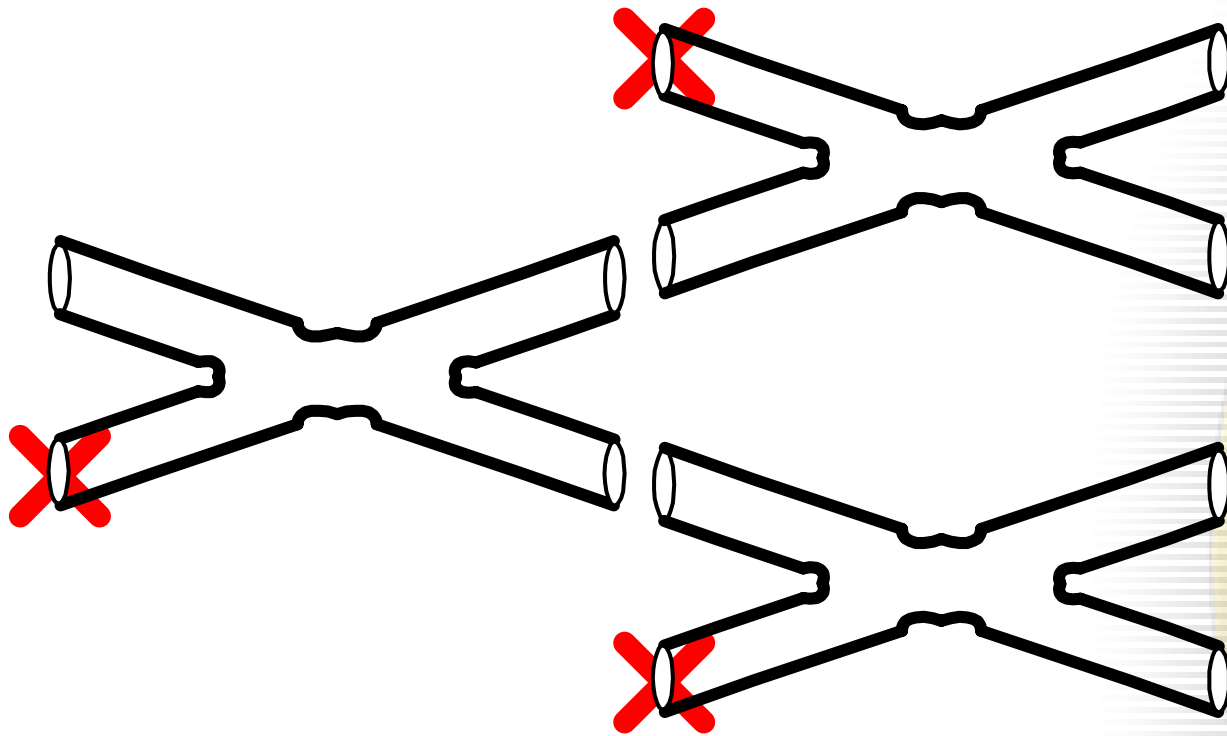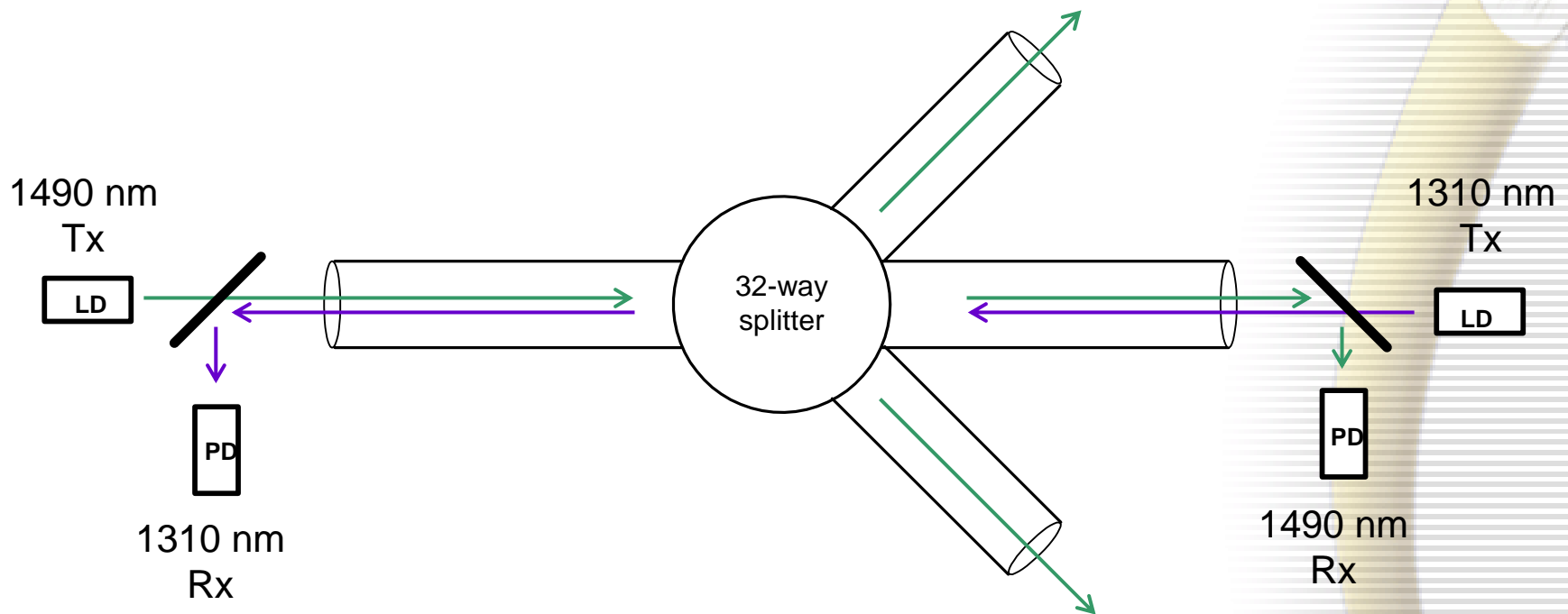Passive
Splitter

ONT

ONT

ONT

The 1x2
Passive Optical Splitter

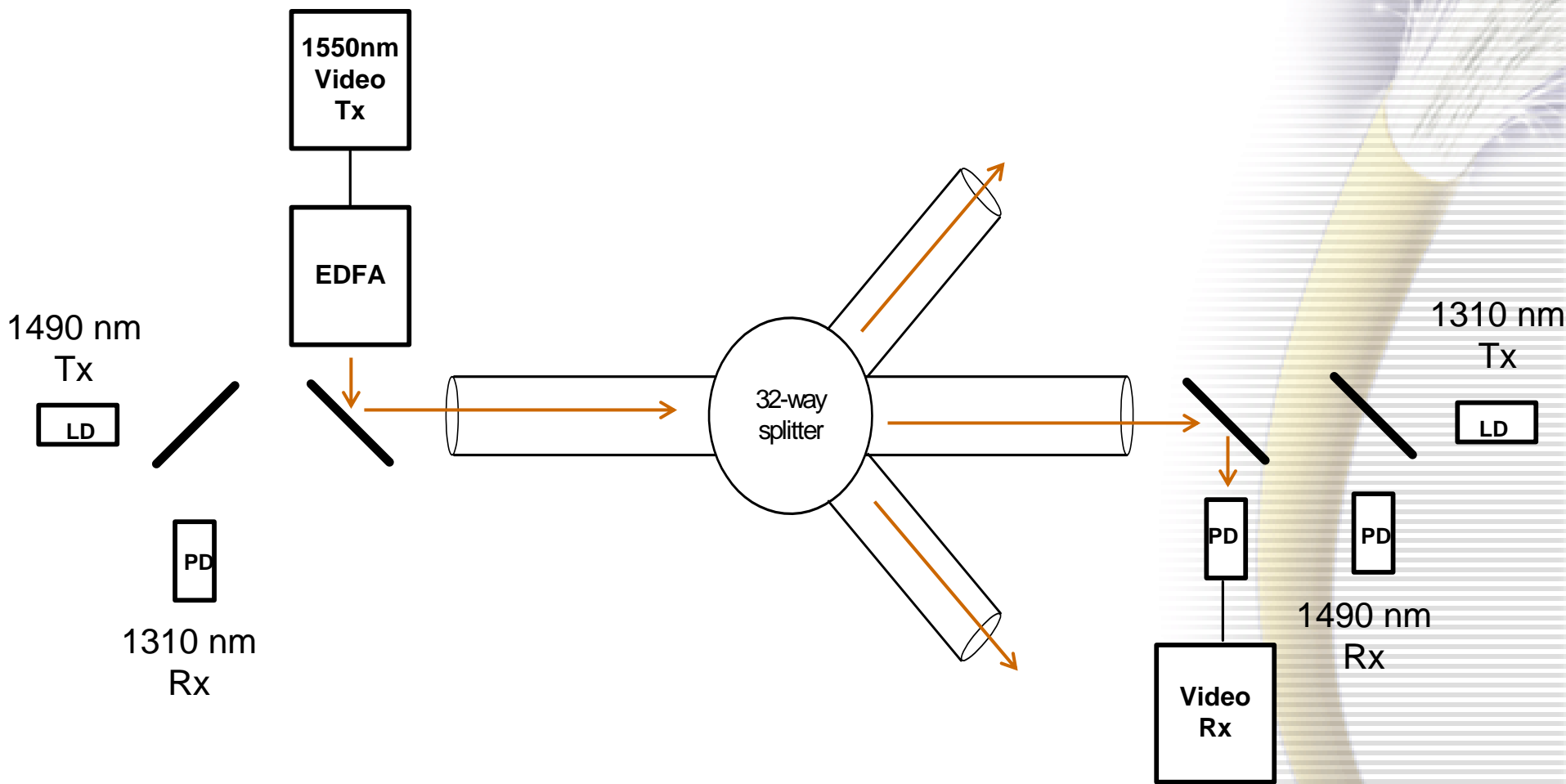# Making a 1x4 splitter
by concatenating 1x2 splitters

Single Fiber Operation

1490 nm
Tx

LD

1310 nm
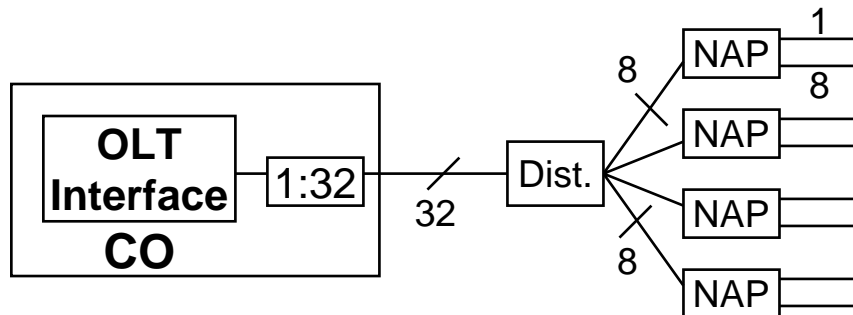Rx

PD

32-way
splitter

1310 nm
Tx

LD

1490 nm
Rx

PD

Single Fiber Operation w/ Video Overlay

PON Network Architectures

PON Architectures
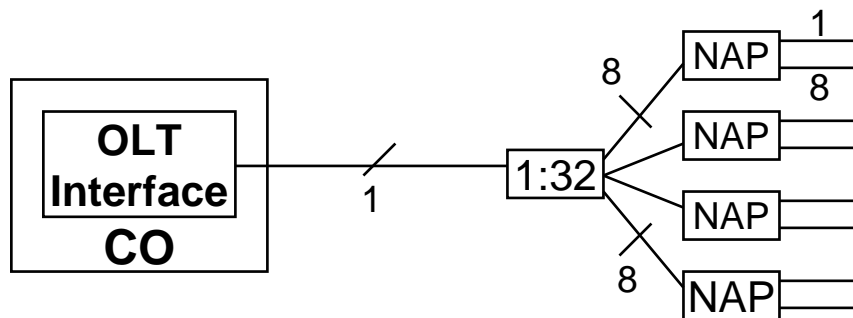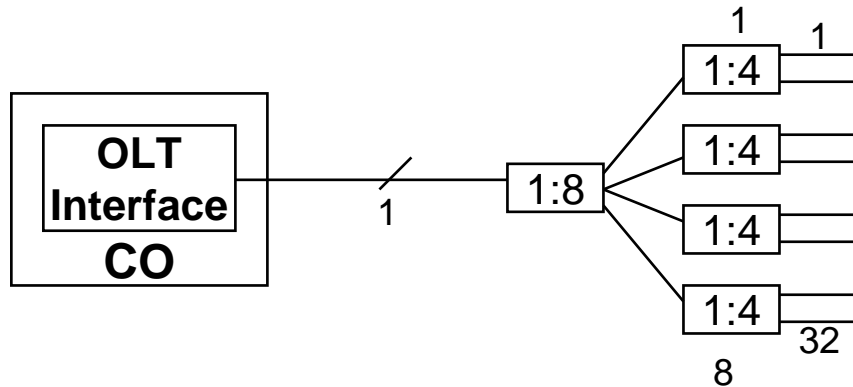
- Distributed Split
1x8 / 1x4 or 1x4 / 1x8

- Centralized Split w/ Network Access Point (NAP)

- Fiber homerun

Distribution Closure

Distribution Cable

Drop Cable

CO / Head End

Feeder Closure

Feeder Closure

Feeder Closure

Feeder Cable
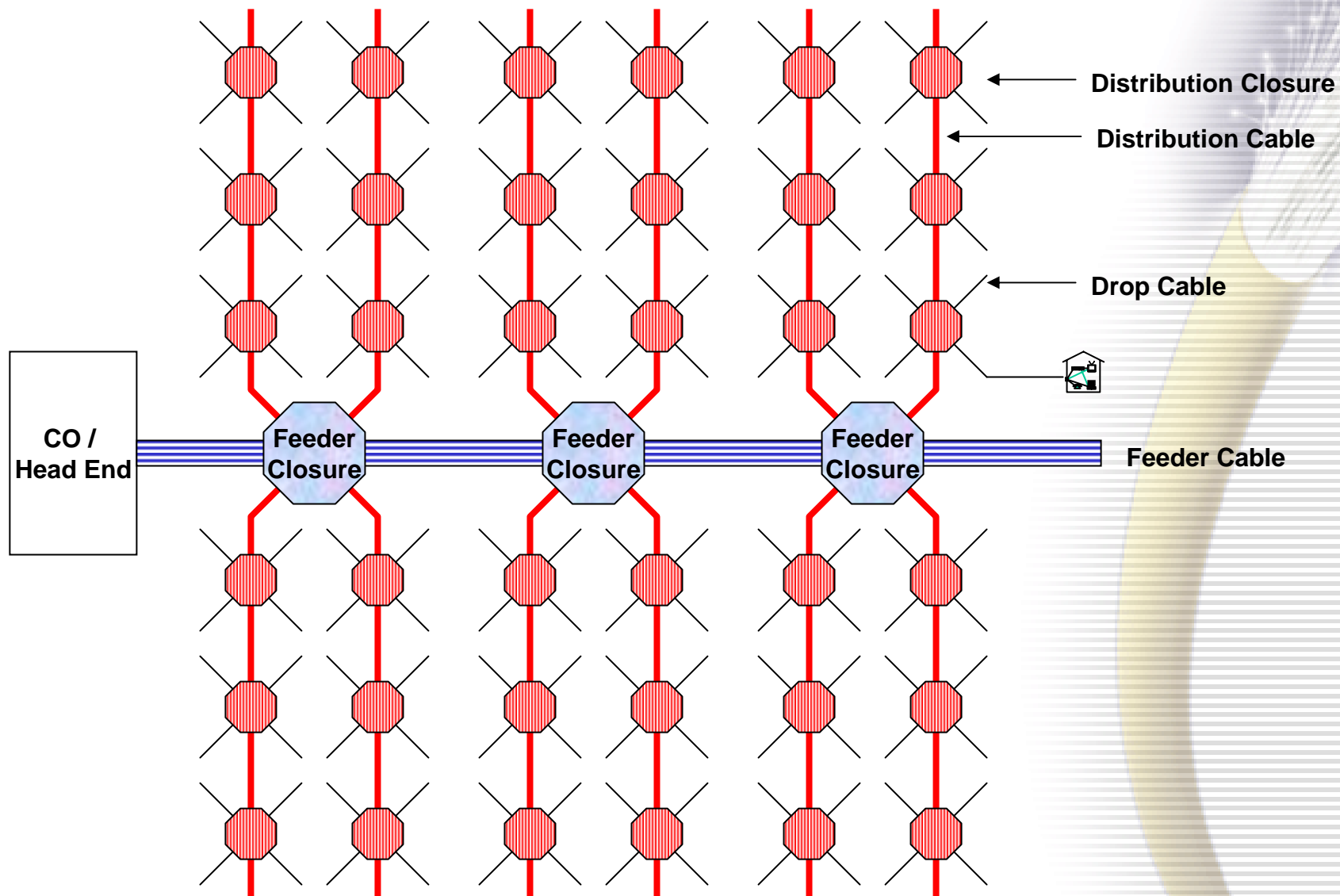
Network Design for 8 City Blocks (4 PONs)

Distribution
cable:
18-fiber
16 utilized

Splice
Closure:
18F to 6F
4 splices

Drop
cable

Feeder:
6-fiber
4 utilized

Feeder
Closure:
four 1x4's
20 splices

Distribution
cable:
6 fiber
2 utilized

Distribution
Closure:
one 1x8
9 splices
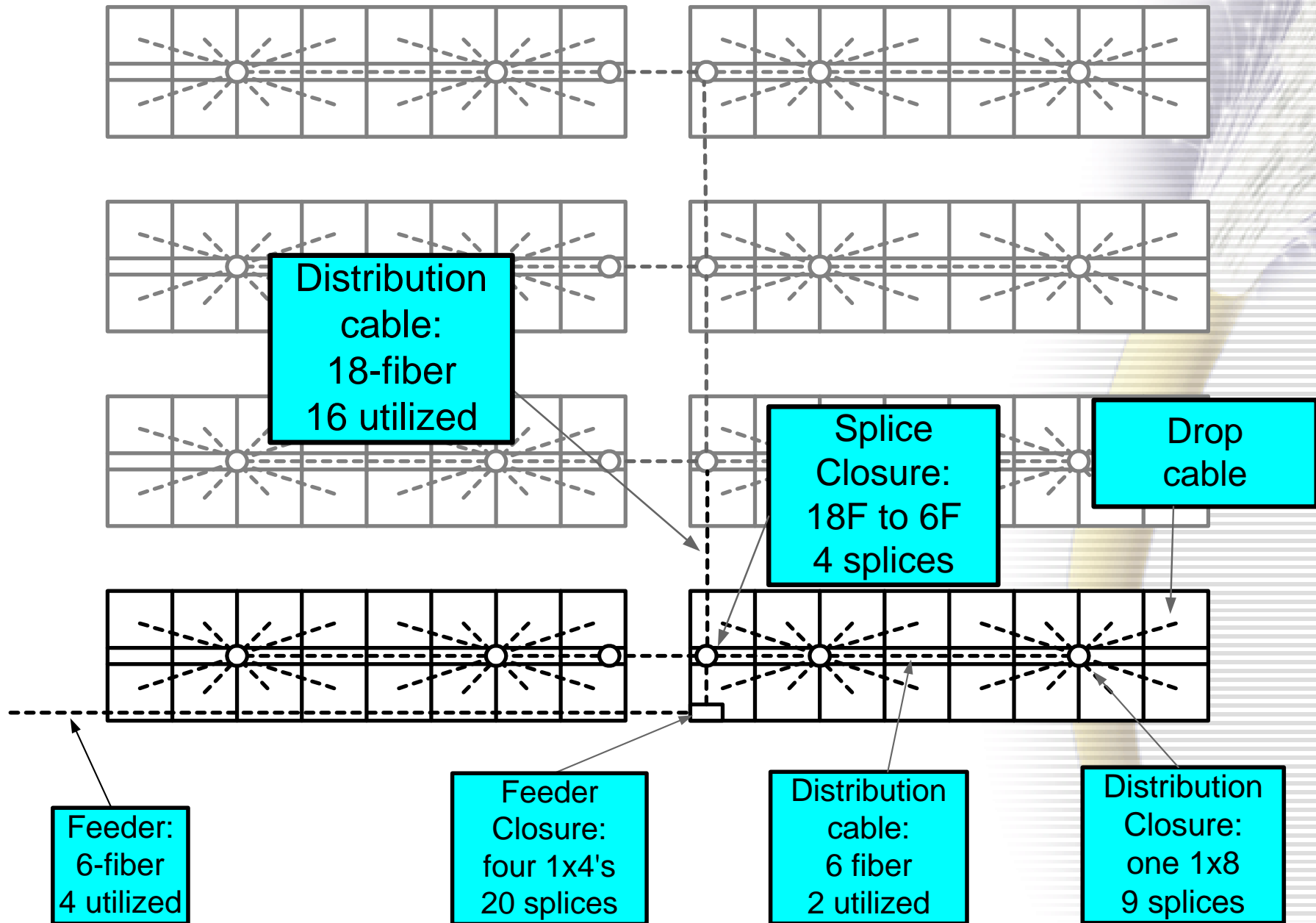
PON Network
with Centralized Split

PON Network
1152 subscribers
5 km reach

(1) x 6-fiber cable

LCP

(3) x 6-fiber cable

(1) x 6-fiber cable

LCP

(1) x 6-fiber cable

LCP

36 splices

(1) x 36-fiber cable

36 splices

(3) x 6-fiber cable

(1) x 6-fiber cable

LCP

(1) x 6-fiber cable

LCP

(1) x 6-fiber cable

LCP
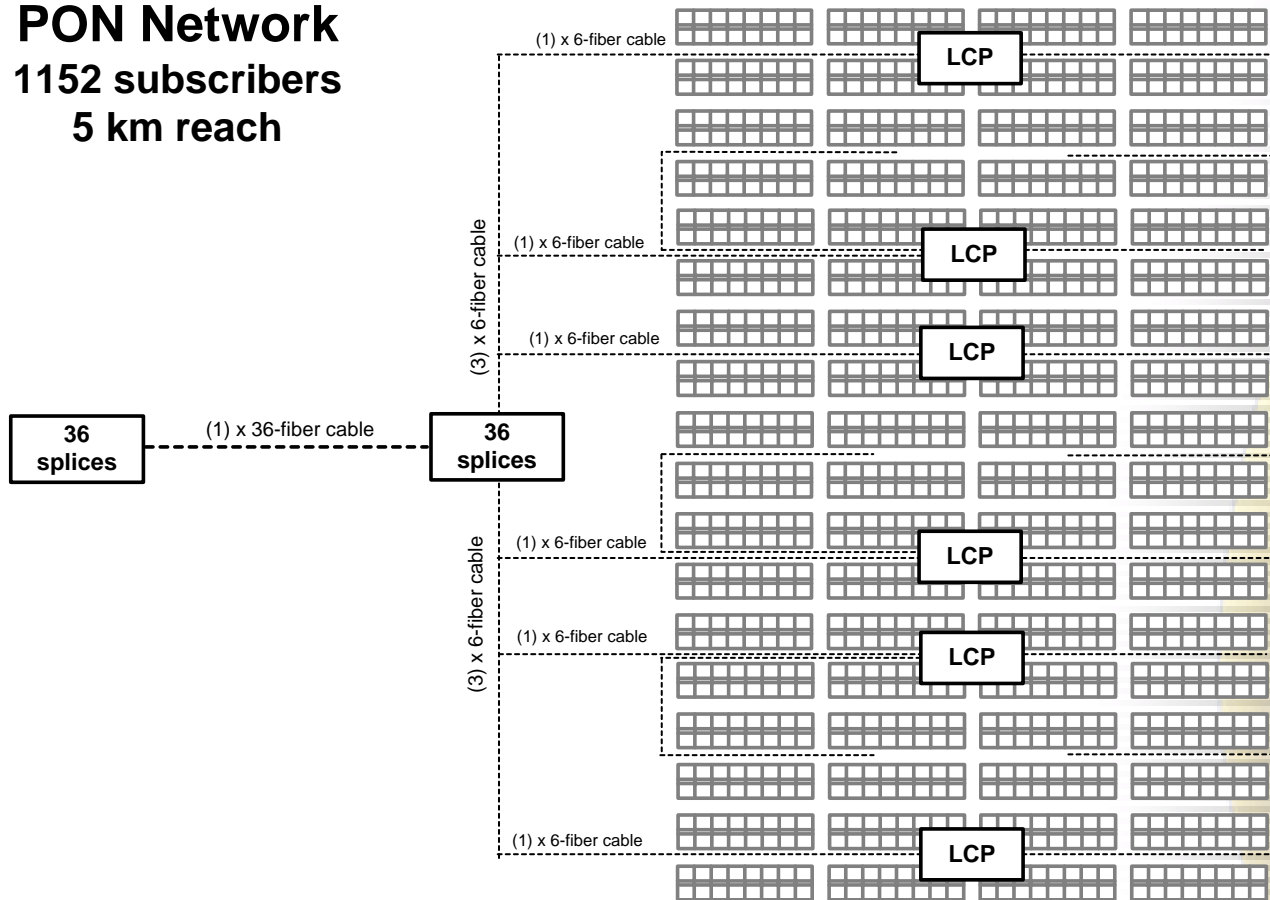
PON Central Office

PON Network
1152 subscribers
5 km reach

Patch Cables
32 x $10

FIber Termination Blocks
1 x $9000

PON OLT

Main Distribution Frame
1 x $3000

MIC cable
36 x $35

Central Office

36 Splices

Outside Plant
(36 fibers)
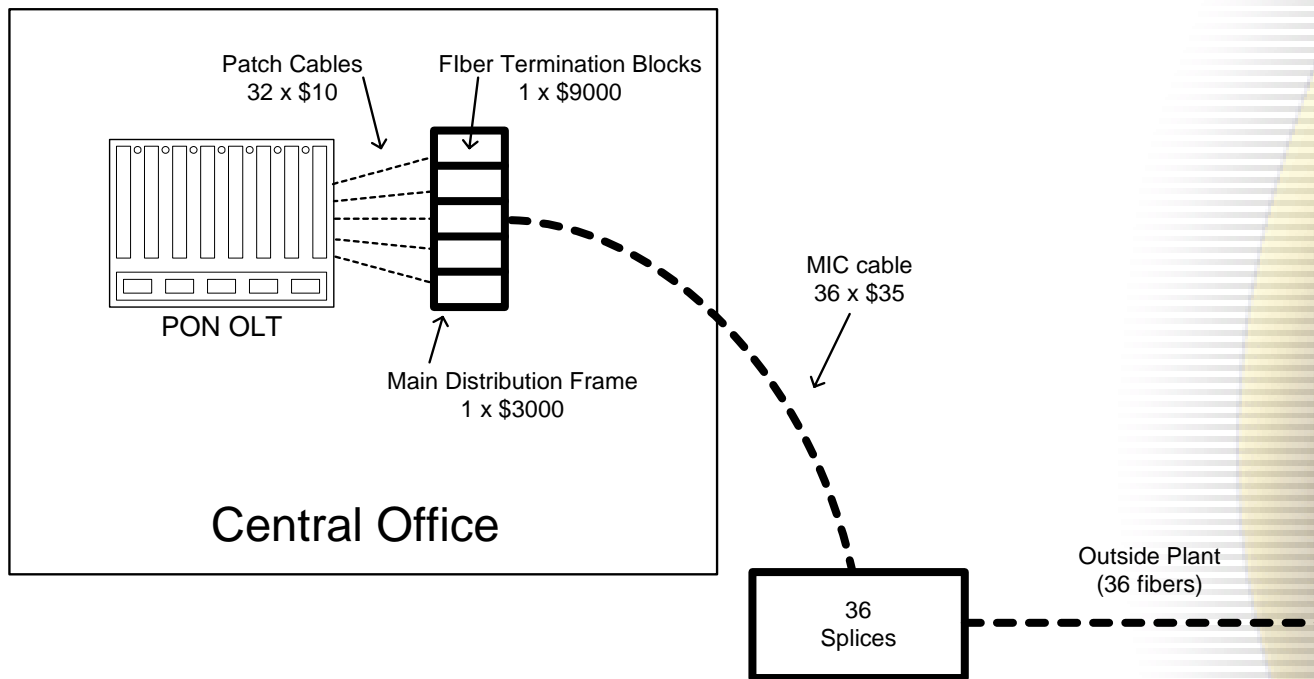
The Transport Layer:

The PON Protocol

Introduction to the PON Protocol

- A PON has a unique network architecture:
  - Point-to-multi-point in the downstream
  - Point-to-point in the upstream
- Because it is unique it requires its own protocol
- A PON protocol ensures the smooth transfer of data in both directions – prevents collisions; grants bandwidth
- Ethernet, IP, or ATM by themselves are not PON protocols – some other underlying protocol is required to maintain operations on the PON

Downstream Broadcast
with PONID or LLID Addressing
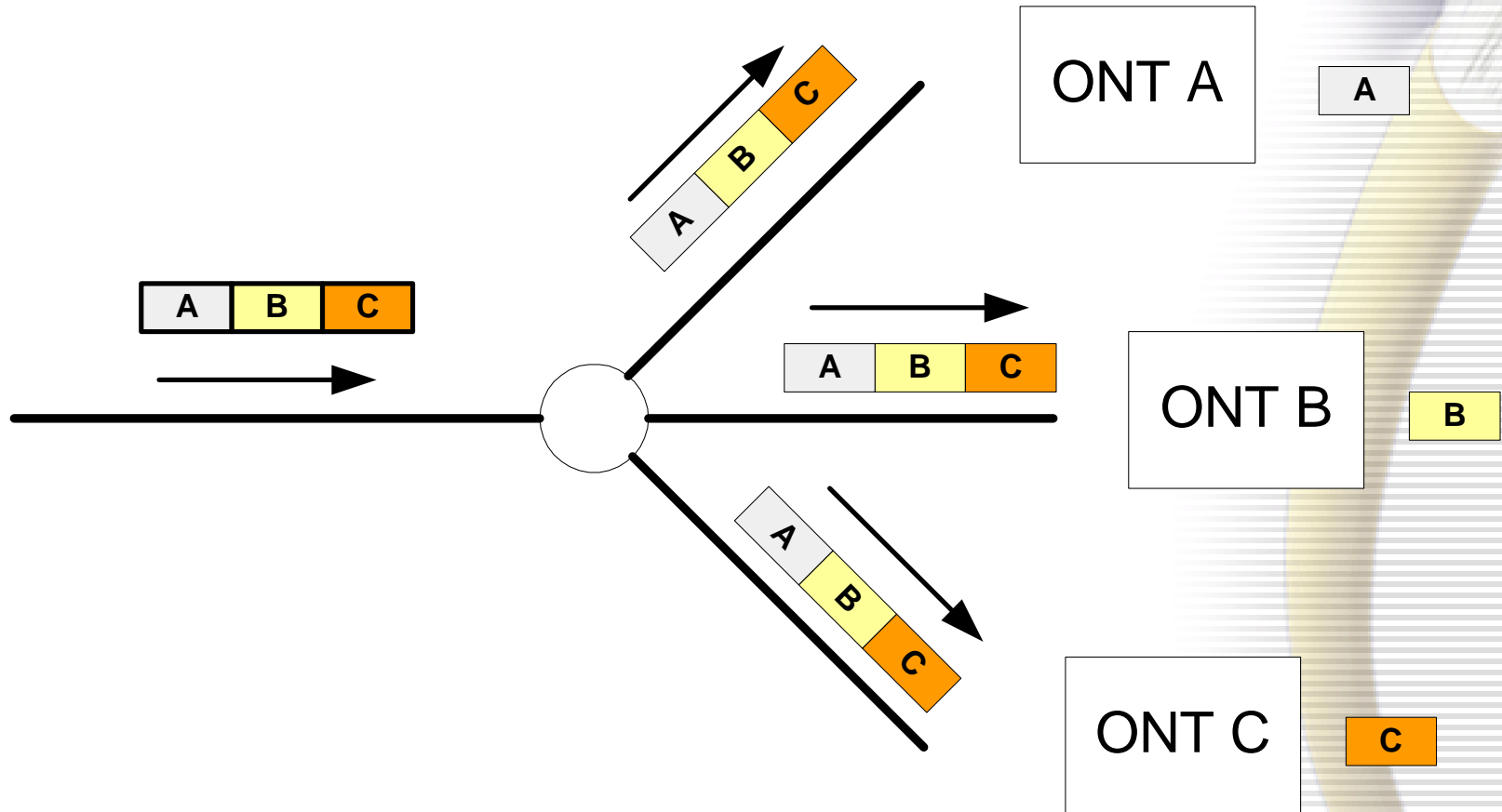
Upstream TDMA with range/delay
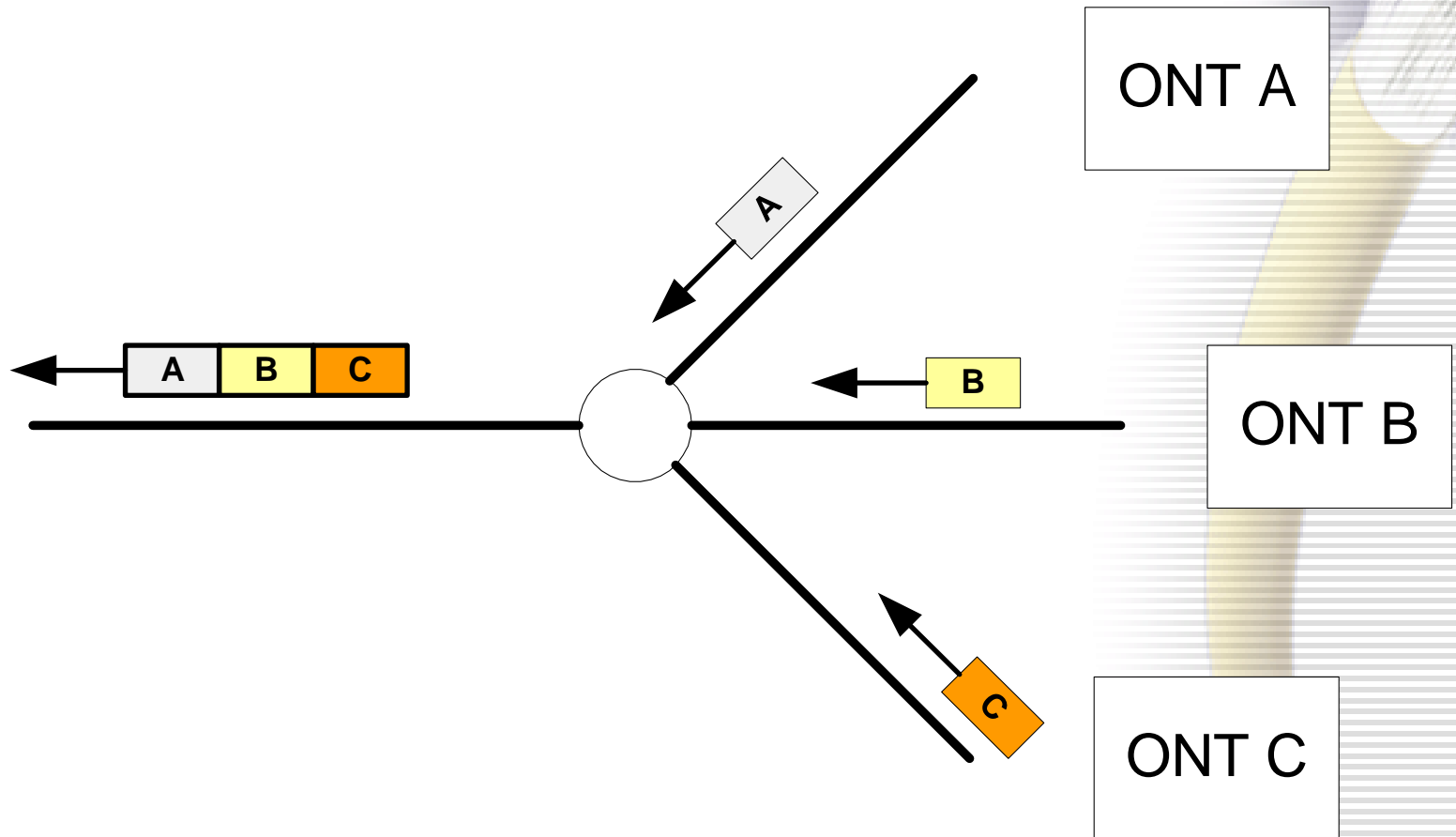
PON Standards

What are the Standards Based Protocols?

- There are two standards bodies that have specified PON protocols:
  - ITU-T
  - IEEE
- From these organizations we now have 3 fully ratified protocols:
  - ITU-T has ratified BPON (G.983) & GPON (G.984)
  - IEEE has ratified EPON (802.3ah)

EPON Standard

- ## Ethernet in the First Mile (EFM)
  - EPON is part of the EFM subcommittee
  - 802.3ah (EFM) is part of the 802.3 (Ethernet) committee
- ## EFM was started in 2001;slated for ratification in 2004
- ## EFM has several network architecture tracks:
  - P2P over Copper
  - P2P over Fiber
  - P2MP over Fiber (a.k.a. EPON)

FSAN PON Standards: BPON vs GPON

- 1st FSAN spec was G.983 - adopted 10/98.
  - This was a first attempt at a PON standard.
  - The first G.983 products were high-cost proof-of-concept demonstrations followed by high-cost FTTB products.
  - Economical BPON products have been on the market for ~3 years.
  - The RBOCs have required this protocol for their first RFP.
  - The G.983 protocol is recognized as limited for FTTH.
    - The G.983 model assumed a single ATM network for converged services - network interface assumed ATM.
    - Timing requirements effectively limit the upstream bandwidth to 155 Mb/s.
    - Does not easily support IPTV.

PON Standards: BPON vs GPON

- Since mid-2001 the FSAN committee has been developing the next generation PON protocol G.984.
  - G.984 acknowledges that OLT can have multiple interfaces including:
    - TDM (DS1s)
    - Gigabit Ethernet
  - G.984 provides for low cost optics at 622 Mb/s and beyond
  - GPON transports both ATM and native Ethernet.

GPON Status and Time Line

- G.984.1 – Service Requirements.
  - Operator's requirements for transport speeds and feeds, tolerances and delays, etc.
  - Ratified by ITU-T in 01/03.
- G.984.2 – PMD – Physical Media Dependent Layer.
  - Link budgets by class, split ratios, etc.
  - Ratified by ITU-T on 01/03.
- G.984.3 – TC - Transmission Convergence Layer.
  - Transport Protocol Layer – similar to layer 2.
  - 09/03: final draft available.
  - 10/03: consented by ITU-T Q2/SG-15.
  - 2/04 : ITU-T ratification.
- G.984.x – future enhancements.
  - Enhancements to GPON are expected over the coming years.

Video over PON

RF Video vs. IP TV

- There are two options for delivering video over a fiber-based access network: RF & IP.

- RF is good, old fashioned video. It modulates the signal (electrical or optical) at radio frequencies to encode the TV signal.

- RF Video <u>content</u> comes in two flavors:
  - Analog video uses amplitude modulation (AM).
  - Digital video uses frequency modulation (FM).

- All RF Video <u>transport</u>, regardless of the type of content, is an analog transport (a.k.a. Broadband).

Considerations for RF Video

- Pros for RF Video:
  - Analog RF Video does not require a set top box at every TV (of course Digital RF Video does).
  - Most existing homes already have existing coax cabling and hence do not need to be re-wired.
- Cons for RF Video:
  - There is little cost savings for RF video.
  - Existing copper plant does not support RF video.

IP TV Background

- IP TV relies on IP/Ethernet to deliver video.
- With IP TV, the content is digital and the transport is digital (baseband).
- Baseband on an optical fiber means the laser is on for a '1' and off for a '0'.
- This digital transport technology is lower cost and can tolerate much lower optical signals.

IP TV Background (cont.)

- IP TV is a catch phrase for any entertainment video over IP.
- IP TV as it applies to the service provider consists of two services: VoD and SDV.
  - Video on Demand: Each TV has it own unique stream of IP packets – IP Unicast.
  - Switched Digital Video: Only one stream of IP packets per video channel and it is shared by multiple TVs – IP Multicast.
  - The two technologies mix well together.

IP TV Background (cont.)

- VoD should grow steadily over the next 10 years.
  - Subscribers must get used to the idea of paying for home video, or…
  - Operators must develop business case for subscription-based VoD.
- SDV is in the midst of an explosive growth phase:
  - Subscribers like it because:
    - It is what they are used to – no cost per view.
    - Noticeably clearer picture than RF.
    - Channel change times are significantly shorter than cable.
  - Operators like it because:
    - Can use it on copper plant as well.
    - Same cost as RF video
    - It allows subscribers to make impulse buys.

Conclusion

- A Passive Optical Network is a low cost architecture for the access network.

- Multiple wavelengths are used to transport voice, video and data over a single fiber.

- We are currently in the midst of a phase of rapid growth for PON deployments.

- This growth is being driven by IP TV.

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